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Role of Summer Legumes in Sustaining the Rainfed Groundnut Productivity

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ABSTRACT

Background: In the face of quickly shifting weather patterns, sustainable agricultural production is essential. The Green Revolution in India led to intensive farming which led to loss of soil biota and degradation of organic matter content resulted in lower soil quality.

Methods: A four-year study (2016 to 2019) was taken up at Regional Agricultural Research station, Tirupati andhra Pradesh, India by growing 6 leguminous crops such as Pillipesara, Rice bean, Sunhemp, Green gram, Horse gram and Cowpea during summer under rainfed condition as a preceding crop and incorporated before sowing of *Kharif* groundnut. FYM was also tested as one of the treatments for comparison.

Result: Results revealed that the choice of green manure crop significantly influenced groundnut yields. Growing and incorporating cowpea before *Kharif* groundnut resulted higher yields (1744 kg/ha) followed by green gram (1699 kg/ha) compared to fallow (1478 kg/ ha). Microbial analysis at the end of the experiment revealed that highest fungal population (28.3 $\times 10^4$ cfu/g) and actinomycet population (24 $\times$ 10^4 cfu/g) was observed in sunhemp followed by cowpea (27$\times 10^4$ cfu/g of soil) and (19.7 $\times$ 10^4 cfu/g) compared to fallow (7 $\times$ 10^4 cfu/g) and (4.7 $\times$ 10^4 cfu/g). The highest bacterial population (33.3 $\times$ 10^6 cfu/g) was observed with green gram followed by horse gram (26.7 $\times$ 10^6 cfu/g) and cowpea (26.3 $\times$ 10^6 cfu/g). The highest organic carbon content (0.5 per cent) was observed with sunhemp followed by horse gram and cowpea (0.49 per cent) compared to fallow (0.45 per cent). Leguminous crops act as cover crops during summer in maintaining the soil temperature and protecting the soil biota and as green manure crops in enriching the soil during *kharif*.

Key words: Groundnut, Legumes, Soil microbes, Summer rainfall, Sustainability, Sustainable agriculture.

INTRODUCTION

The sustainable production of agricultural products is imperative in the context of rapidly changing climate, which pose a significant threat to global food production. In India, the Green Revolution successfully met the needs of the growing population, but has taken a toll on soil quality, diminishing organic matter content and destroying crucial soil biota (Gardi *et al.,* 2013). To restore the degraded soil health, cover crops, mulching and other organic management practices like incorporation of green manure etc. are used along with growing pulses. Green manure helps in gaining back the deteriorated soil quality (Israt and Parimal, 2023). It would improve the nutrient status of the soil and also increase the soil biota. The choice of an appropriate species of legume has a great impact on the amount of biomass, N accumulation and rate of nutrient release into the available forms (Jyoti *et al*., 2023). Live mulch, without the need for long fallow periods, is suggested as a strategy for sustaining yields. Mulching not only contributes to soil temperature regulation but also enhances soil structure infiltration rate and stimulates microbial and meso-faunal activity. Furthermore, mulching plays a role in carbon stock by promoting mineralization and reducing erosion (Nandwa, 2001). The impact of organic management on microbial communities, specifically bacterial populations and enzyme activities, has been well-documented. However, the effects of organic modification on soil organic matter (SOM) traits and functioning, particularly in combination with cover crops, remain largely unknown. Recent studies highlight the potential of organic agriculture to increase SOM content by incorporating substantial amounts of carbon into the soil, leading to an observed increase in soil organic carbon (SOC) stocks in organic farming (Gattinger *et al.,* 2012: Lori *et al.,* 2017). Cover crops, in addition to increasing microbial biomass and activity, induce changes in microbial community structure, making them integral to sustainable agricultural practices (Buyer *et al.,* 2010).

Amidst the ongoing climate change scenario, characterized by rising temperatures and increased monsoon irregularities, crop production in rainfed areas is

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challenging due to intermittent droughts. Decreased organic matter and unpredictable rainfall patterns significantly impact dryland agriculture. IN addition, producing sustainably is becoming essential to food systems and agriculture (De Ruiter *et al.,* 1993). Because they provide a variety of benefits in accordance with sustainability principles, legume crops have the potential to be very significant in this context (Stagnari *et al.,* 2017). Actions such as appropriate crop rotation are recommended to sustainably manage soil resources and ensure long-term agricultural viability (Derner and Schuman, 2007; Lal, 2009). Recognizing the need for sustainable alternatives, this study explores the efficacy of leguminous crops as a protective soil cover during summer and also an organic management strategy on rainfed groundnut productivity. This study also aims to contribute insights into maintaining soil fertility, productivity and carbon sequestration, thereby reducing the greenhouse effect.

MATERIALS AND METHODS

Location and design

Experiment was taken up at Regional Agricultural Research station, Tirupati, Andhra Pradesh, India. Experiment was laid out in randomized block design with three replications. The test crop groundnut was raised in plots of 8 × 5 m with a spacing of 30 × 10 cm. A recommended fertilizer dose of 20, 40, 50 kg N, P_2O_5 and K_2O/ha was applied at sowing followed by 500 kg /ha of gypsum was top dressed during flowering stage. The experiment was conducted for 4 years consecutively from 2016 to 2019.

Treatments

The preceding legume crops grown were Pillipesara (*Vigna tribolata*), rice bean (*Vigna Umbellata*), sunhemp (*Crotalaria juncea*), green gram (*Vigna radiata*), horse gram (*Macrotyloma uniflorum*), Cowpea (*Vigna unguiculata*). Farm Yard Manure (FYM) was also used as a treatment in the experiment. An absolute control was also maintained. The treatments were designated as, T1: Pillipesara - Groundnut, T2: Rice bean - Groundnut, T3: Sunhemp - Groundnut, T4: Green gram - Groundnut, T5: Horse gram - Groundnut, T6: Cowpea - Groundnut, T7: FYM - Groundnut, T8: Control. The preceding legume crops were sown at the receipt of sufficient rainfall during the month of May every year. In situ incorporation of these legume crops was taken up at the time of 50% flowering (Table 1).

RESULTS AND DISCUSSION

kharif 2016

Among different legume crops tried during summer before sowing of groundnut during *kharif* 2016, the highest groundnut yields (1405 kg/ha) were recorded when cowpea was taken as base legume crop before groundnut followed by farm yard manure applied treatment before sowing of groundnut (1363 kg/ha) (Table 2). The least groundnut yield was recorded with rice bean sown as preceding crop before sowing of groundnut (811 kg/ha). The groundnut crop received 168 mm rainfall only during crop growth period hence three irrigations, one during pegging stage and two irrigations during pod development stage has given to protect the crop.

kharif, 2017

Legume crops were sown with 11 mm of rainfall on 21st May and incorporated after 31 days. In the same plots groundnut crop was sown and a maximum groundnut yield (2193 kg ha^{-1}) was recorded with cowpea as preceding crop followed by farm yard manure applied plots (2008 kg/ha)

Table 1: Dates of sowing of preceding legume crops, dates of incorporation, rainfall received for all the four years.

Year	Date of sowing of green manure crops	Rainfall received during green manure crop period	Date of incorporation	Date of sowing of groundnut crop	Rainfall received during groundnut crop period	Date of harvest of groundnut crop
2016	07/05/2016	329.5 mm	01/07/2016	28/07/2016	168.1 mm	29/11/2016
2017	21/05/2017	91.4 mm	20/06/2017	14/07/2017	856.4 mm	04/11/2017
2018	01/05/2018	129.8 mm	26/06/2018	14/07/2018	346.4 mm	04/11/2018
2019	29/05/2019	86.8 mm	17/07/2019	09/08/2019	724.4 mm	26/11/2019

Table 2: Yield and yield attributes of Groundnut *Kharif*, 2016.

Treatment	Pod yield (kg/ha)	100 pod wt (g)	No. of filled pods	Shelling (%)	Haulm yield (kg/ha)
T1: Pillipesara-Groundnut	963	68.7	4.7	71.6	2320
T2: Rice bean-Groundnut	811	64.0	5.3	68.6	2482
T3: Sunhemp-Groundnut	965	71.3	5.7	73.7	3200
T4: Green gram-Groundnut	1175	67.7	6.7	74.0	2883
T5: Horse gram-Groundnut	1240	69.6	7.3	75.0	3196
T6: Cowpea-Groundnut	1405	71.0	8.0	73.0	2699
T7: FYM-Groundnut	1363	70.7	7.3	76.7	3298
T8: Control	851	67.3	5.6	60.7	2256
CD (0.05)	98.02	NS	1.37	NS	225

(Table 3). The minimum groundnut yield was recorded with sunhemp (1703 kg/ha). The groundnut crop received 854 mm rainfall during its crop period and took 114 days duration.

***kharif*, 2018**

Legume crops were sown with 21.4 mm of rainfall on 1st May and insitu incorporated after 56 days. After 18 days, groundnut was sown and a highest groundnut yield (1581 kg ha^{-1}) was recorded with green gram as a preceding crop followed by cowpea (1191 kg ha^{-1}) (Table 4). The least groundnut yield was recorded with pillipesara (785 kg ha^{-1}). The legume crops received 129.8 mm rainfall and groundnut crop received 256.4 mm rainfall during its crop period.

***kharif*, 2019**

Legume crops were sown with 8.0 mm of rainfall on 29th May and insitu incorporated after 50 days. In the same plots, groundnut was sown after 23 days. During this year, no much difference was found among all the treatments on pod yield as well as other auxillary characters and was observed to be non-significant (Table 5). In summer, during crop period of legume crops only 102 mm rain was received in 2 rainy days due to which the biomass of legume crops was observed to be very poor. During the crop period of groundnut 724.4 mm rainfall was received in 40 rainy days with good distribution. This rainfall effect masked the benefit of raising legume crops prior to *kharif* groundnut during the year.

Pooled results of the experiment (*kharif*, 2016-2019)

Pooled analysis revealed that growing summer legumes as preceding crop during summer rains maintained the soil health by reducing soil temperatures and increasing the soil biota and assisted in better performance of *Kharif* Groundnut. Among different legumes crops incorporated, *in-situ* incorporation of cowpea resulted in a higher groundnut production (1744 kg/ha) followed by green gram

Table 3: Yield and yield attributes of groundnut *Kharif*, 2017.

Treatment	Pod yield kg/ha	100 pod wt	No. of filled pods	Shelling %	Haulm yield kg/ha
T1: Pillipesara -Groundnut	1818	98	11.67	68.67	1943
T2: Rice bean-Groundnut	1901	102	12.67	76.33	2173
T3: Sunhemp-Groundnut	1703	97.33	15	67	2327
T4: Green gram-Groundnut	1712	97	11	65.33	2440
T5: Horse gram - Groundnut	1718	97	9.33	67.67	2363
T6: Cowpea - Groundnut	2193	102.67	15	80.33	1623
T7: FYM - Groundnut	2008	106.33	11.67	81.67	2263
T8: Control	1788	96	11	66.67	2157
CD (P=0.05)	306.28	3.87	2.212	2.212	NS

Table 4: Yield and yield attributes of groundnut *Kharif*, 2018.

Treatment	Pod yield kg/ha	100 pod wt	No. of filled pods	Shelling %	Haulm yield kg/ha
T1: Pillipesara -Groundnut	785	86.5	10.67	68.67	4757
T2: Rice bean-Groundnut	868	95.5	11	67.33	3840
T3: Sunhemp-Groundnut	1135	101.1	11.67	74.33	3847
T4: Green gram-Groundnut	1581	101.1	12.67	76	4073
T5: Horse gram - Groundnut	975	98.5	10.33	69.333	3093
T6: Cowpea - Groundnut	1191	90.3	11.67	73.67	3577
T7: FYM - Groundnut	1025	95.4	12	73.67	3647
T8: Control	887	93.2	9.67	72	3530
CD(P= 0.05)	154.90	NS	NS	4.422	833.6

Table 5: Yield and yield attributes of groundnut *Kharif*, 2019.

Treatment	Pod yield kg/ha	100 pod wt	No. of filled pods	Shelling %	Haulm yield kg/ha
T1: Pillipesara -Groundnut	2394	125	11.6	70.68	2617
T2: Rice bean-Groundnut	2341	118	9.70	69.33	2900
T3: Sunhemp-Groundnut	2102	123	10.60	73.00	2583
T4: Green gram-Groundnut	2329	125	9.60	70.67	2183
T5: Horse gram - Groundnut	2074	123	12.00	70.00	2366
T6: Cowpea- Groundnut	2186	123	11.33	70.00	2650
T7: FYM - Groundnut	2178	123	11.33	73.00	2790
T8: Control	2245	117	12.00	73.00	2583
CD (P= 0.05)	NS	NS	NS	NS	NS

(1699 kg/ha) which are comparable (Table 6). Furthermore, application of FYM during summer rains also found to be next best alternative to cowpea and green gram in achieving groundnut yield (1609 kg/ha). The percentage increase of ground nut yields from in-situ incorporation of cowpea over control is 18.6%. The higher yields of groundnut with in-situ incorporation of cowpea might be due to the addition of higher amount of nutrient rich biomass combined with higher soil organic carbon that might have provided the sustainable availability of micro and macro nutrients for the succeeding crop eventually resulting in higher yield and yield attributes of ground nut crop. Ramanjaneyulu *et al.* (2021) reported higher addition of biomass with in-situ incorporation cowpea compared to other legumes. In addition to that, in-situ incorporation of cowpea has also resulted in enhanced water holding capacity and microbial activity which have a significant impact on soil health thus improve in performance of ground nut crop. Nikita *et al.* (2015) has reported increase in yields of sweet corn with in-situ incorporation of green manures compared to control. Chaitanya Kumar *et al.* (2022) recorded higher yields of chickpea with in-situ incorporation of cowpea when compared to green gram and pillipesara. Similar nature of results was also reported by rani *et al.* (2022). The least yields of ground nut were recorded with control.

Microbial population in different green manure treatments

The Soil microbial populations in different legume crops sown before groundnut revealed the highest fungal population (28.3×10^4 cfu/g) and actinomycet population (24×10^4 cfu/g) in sunhemp followed by cowpea plots (27×10^4cfu/g) and (19.7×10^4 cfu/g) (Table 7 and Plate 1 and 2). The highest bacterial population (33.3×10^6 cfu/g) was observed with green gram followed by horse gram (26.7×10^6 cfu/g) and cowpea (26.3×10^6 cfu/g). Legume incorporation treatments found to be superior in maintaining soil health compared to FYM application. In a study conducted by Muhammad *et al.* (2021) revealed that in comparison to no cover crop, the overall number of bacteria and fungus in the soil as well as their respective groups increased by 7-31%.

Soil organic carbon

The initial soil organic carbon of the experimental field is 0.39. Over a period of years, the organic carbon in all the treatments has increased. The highest soil organic carbon content (change as 5.0 g kg^{-1}) was observed with sun hemp followed by horse gram and cowpea (4.9 g kg^{-1} per cent) compared to fallow (4.5 g kg^{-1} per cent) (Table 8). The least values of soil organic carbon were recorded with control.

Table 6: Yield and yield attributes of Groundnut (pooled analysis of 2016-2019).

Treatment	Pod yield (kg/ha)	Haulm yield (kg/ha)	100 pod wt. (gms)	Filled pods (No)	Shelling per cent (%)
T1: Pillipesara -Groundnut	1490 ^{b}	2909 ^{ab}	94.5 ^{ab}	9.7 ^{cd}	69.8 ^{b}
T2: Rice bean-Groundnut	1480 ^{b}	2849 ^{ab}	94.9 ^{ab}	9.9 ^{bcd}	72.4 ^{b}
T3: Sunhemp-Groundnut	1699 ^{a}	2895 ^{ab}	98.3 ^{a}	11.1 ^{ab}	72.0 ^{b}
T4: Green gram-Groundnut	1476 ^{b}	2989 ^{a}	97.7 ^{ab}	10.2 ^{bcd}	71.9 ^{b}
T5: Horse gram - Groundnut	1502 ^{b}	2755 ^{ab}	97.1 ^{ab}	9.2 ^{d}	70.6 ^{b}
T6: Cowpea - Groundnut	1744 ^{a}	2637 ^{b}	96.8 ^{ab}	12 ^{a}	73.2 ^{b}
T7: FYM -Groundnut	1609 ^{ab}	3000 ^{a}	98.9 ^{a}	10.5 ^{bc}	76.4 ^{a}
T8: Control	1470 ^{b}	2631 ^{b}	93.1 ^{a}	9.5 ^{cd}	72.2 ^{b}
			F-Value		
Year	225**	61.2**	376.9**	93.8**	NS
Year vs treatments	3.1**	2.4**	NS	2.4**	3**
Treatments	3.8*	NS	NS	5.6**	3.5*

Table 7: Microbial population in different green manure treatments, 2019.

Treatment	Fungi PDA ($\times 10^4$/g of soil (cfu/g)	Bacteria NA ($\times 10^6$)/gof soil (cfu/g)	Actinomycetes KA ($\times 10^4$) g of soil (cfu/g)
T1: Pillipesara-Groundnut	12.0	11.3	15.0
T2: Rice bean-Groundnut	18.0	14.0	13.0
T3: Sunhemp-Groundnut	28.3	19.0	19.7
T4: Green gram-Groundnut	16.0	33.3	18.0
T5: Horse gram-Groundnut	12.3	26.7	14.0
T6: Cowpea-Groundnut	27.0	26.3	24.0
T7: FYM-Groundnut	16.0	17.3	11.7
T8: Control	7.0	5.7	4.7

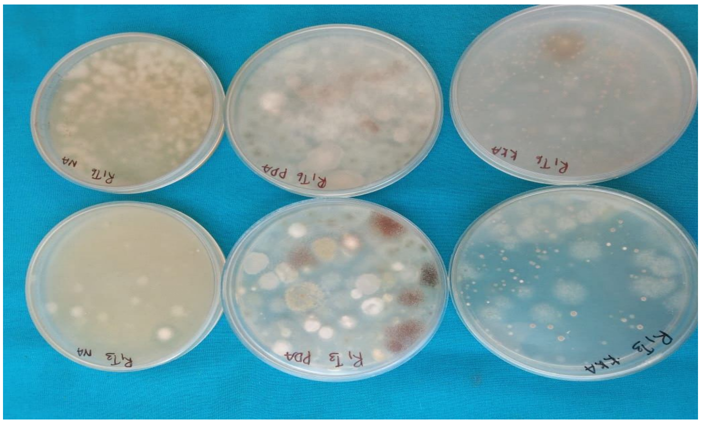

Plate 1: Microbial population in different green manure treatments.

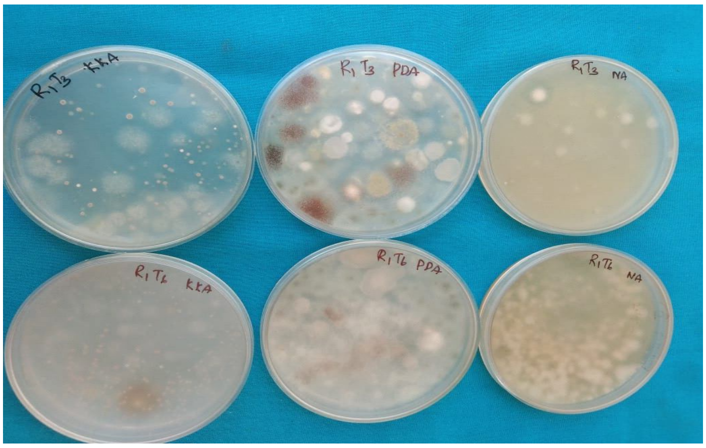

Plate 2: Microbial Population in different green manure treatments.

Table 8: Initial and final organic carbon in different green manure treatments, 2019.

Treatment	Initial O.C (%)	Final O.C (%)
T1: Pillipesara-Groundnut	0.39	0.45
T2: Rice bean-Groundnut	0.39	0.45
T3: Sunhemp-Groundnut	0.39	0.51
T4: Green gram-Groundnut	0.39	0.46
T5: Horse gram-Groundnut	0.39	0.49
T6: Cowpea-Groundnut	0.39	0.49
T7: FYM-Groundnut	0.39	0.47
T8: Control	0.39	0.42

CONCLUSION

The present investigation confirms a positive and significant impact due to in-situ incorporation of legume green manures on yield of succeeding ground nut crop. Among the different treatments tried, cowpea in-situ incorporation has resulted in higher yields of ground nut along with higher microbial population. The least yield and microbial population were observed with control. Instead of leaving land fallow, in-situ incorporation of legume green manures protect soil from erosion and loss of nutrients and also restore the soil health.

Conflict of interest

Authors are unaware of any conflict of interests.

REFERENCES

Buyer, J.S., Teasdale, J.R., Roberts, D.P., Zasada, I.A. and Maul, J.E. (2010). Factors affecting soil microbial community structure in tomato cropping systems. Soil Biol. Biochem. 42: 831-841.

Chaitanya Kumar, G., Vijaya Bhaskar Reddy, U., Ramesh Babu, P.V. and Kavitha, P. (2022). Effect of different green manuring crops and fertilizer doses on growth and yield of chickpea (*Cicer arietinum* L.) at scarce rainfall zone of Andhra Pradesh, India. Int. J. Environ. Clim. 12(11): 744-750.

De Ruiter, P.C., Van Veen, J.A., Moore, J.C., Brussaard, L. and Hunt, H.W. (1993). Calculation of nitrogen mineralization in soil food webs. Plant Soil.157: 263-273.

Derner, J.D. and Schuman, G.E. (2007). Carbon sequestration and rangelands: A synthesis of land management and precipitation effects. Journal of Soil and Water Conservation. 62(2): 77-85.

Gardi, C., Jeffery, S. and Saltelli, A. (2013). An estimate of potential threats levels to soil biodiversity in EU. Glob. Change Biol. 19: 1538-1548.

Gattinger, A., Muller, A., Haeni, M., Skinner, C., Fliessbach, A., Buchmann, N., Mader, P., Stolze, M., Smith, P., Scialabba, N.E.H. and Niggli, U. (2012). Enhanced top soil carbon stocks under organic farming. Proc. Natl. Acad. Sci. 109: 18226-18231.

Israt, I.J. and Parimal, B.K. (2023). Residual effect of green manure on soil properties in green manure-transplant aman-Mustard cropping pattern. Indian Journal of Agricultural Research. 57(1): 67-72. doi: 10.18805/IJARe.AF-696.

Jyoti, J., Kalidas, U., Baby, L. and Rozar, K.P. (2023). Assessment of Some Leguminous Weeds as Potential Green Manure Crops under Mizoram, North East India. Legume Research. 46(12): 1686-1691. doi: 10.18805/LR-5196.

Lal, R. (2009). Challenges and opportunities in soil organic matter research. Eur. J. Soil Sci. 60: 158-169.

Lori, M., Symnaczik, S., Mader, P., De Deyn, G. and Gattinger, A. (2017). Organic farming enhances soil microbial abundance and activity-a meta-analysis and meta-regression. PLoS One. 12: e0180442.

Muhammad, I., Wang, J., Sainju, U.M., Zhang, S., Zhao, F. and Khan, A. (2021). Cover cropping enhances soil microbial biomass and affects microbial community structure: A meta-analysis. Geoderma. 381(1): 114696. https://doi.org/10.1016/j.geoderma.2020.114696.

Nandwa, S.M. 2001. Soil organic carbon (SOC) management for sustainable productivity of cropping and agro-forestry systems in Eastern and Southern Africa. Nutr. Cycl. Agroecosystems. 61(1): 143-158. doi: 10.1023/A:1013386710419.

Nikita, C., Patel, P.H. and Patel, A.G. (2015). Growth, yield and economics of rabi sweet corn (*Zea mays*) as affected by green manuring crops and nitrogen management. Trends in Biosciences. 8(8): 1943-1949.

Ramanjaneyulu, A.V., Sainath, N., Swetha, D., Reddy, R.U. and Jagadeeshwar, R. (2021). Green manure crops-a review. Biological Forum. 13(2): 445-455.

Rani, Y.S., Jamuna, P., Triveni, U., Patro, T.S.S.K. and Anuradha, N. (2022). Effect of in-situ incorporation of legume green manure crops on nutrient bioavailability, productivity and uptake of maize. J. Plant Nutr. 45(7): 1004-1016. https://doi.org/10.1080/01904167.2021.2005802.

Stagnari, F., Maggio, A., Galieni, A. and Pisante, M. (2017). Multiple benefits of legumes for agriculture sustainability: An overview. *Chem.* Biol. Technol. Agric. 4: 2. https://doi.org/10.1186/s40538-016-0085-1.